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ART. I.—*On the Minute Structure of the Hepatic Lobules, particularly with reference to the Relationship between the Capillary Bloodvessels, the Hepatic Cells, and the Canals which carry off the Secretion of the latter.* By H. D. SCHMIDT, M. D., of Philadelphia. (Illustrated with 33 Figures.)

SEVERAL months since, in examining the microscopical structure of the liver, I obtained very unsatisfactory results from a mere superficial examination. The great discrepancy of opinion existing among the best histologists of the present day in regard to the minute anatomy of this organ attracted my attention, and, wishing to satisfy myself on this point, I determined to make it a special subject of investigation.

The modes I adopted for this have perhaps enabled me to work with greater advantage than others.

When we consider the complex structure of this organ, we need not wonder that the best microscopists have been baffled in the attempt to unravel its minute anatomy; though it is in some instances astonishing that their opinions should be so widely different.

The following pages are devoted only to the consideration of the minute structure of *the hepatic lobule, or the relationship existing between the capillary bloodvessels, the hepatic cells, and those passages or canals destined to carry off the secretion of the latter.*

Although I have examined the liver of several animals, yet I preferred for special investigation those of the sheep and hog. The liver of the latter has generally been recommended as being most suitable for investigation; but for injecting (although the difference is slight) I prefer that of the sheep. The portal vein and hepatic duct in the latter (like in that of man)

branch out at acute angles, and consequently offer less resistance to the passage of the injection, than in the hog in which the branches of the interlobular vessels mostly come off at right angles with the periphery of the lobule, so that a greater pressure is required to send the injection into them.

Since commencing these investigations I have endeavoured to obtain healthy human livers, but have as yet succeeded in only one instance. In this, unfortunately, the vena cava had been cut off so close to the organ, that it prevented me from throwing an injection into the hepatic veins; nevertheless, I injected the other vessels, and the examination proved satisfactory, though I did not consider the injection sufficiently perfect to serve for thorough investigation. I shall therefore postpone to a future period the investigation of the microscopical anatomy of the human liver.

Before proceeding further, it may perhaps be useful to cite the views of different observers on the subject.

E. H. WEBER[1] has been led to the conclusion that the bile-ducts form a network, the meshes of which fit exactly in that of the capillary bloodvessels of the liver. Both these networks are interwoven in such a manner that the one fills up the interspaces left by the other. The bile-ducts nowhere anastomose with the blood-carrying capillary system, but both classes of canals touch each other only on the sides of their walls. He further remarks that the rows of cells in the liver are true canals (this he proved by injections), and these form a network, the tubes of which are of the same diameter as the finest bile-ducts injected by him.

KRUCKENBERG,[2] who also injected a network of bile-ducts interwoven with the capillary blood system of the liver, is more cautious in his explanation than Weber. He believes that the hepatic cells lie in reticularly arranged tubes (finest bile-ducts), the walls of which, being very thin, were invisible. The latter, from being torn so easily, and on account of their reticular arrangement and intimate interweaving with the capillaries, could not be demonstrated. At the same time he refers to the uriniferous tubules, which, formed by the union of peculiar cells by means of a structureless membrane, have not always a visible tube.

THEILE[3] also believes in the existence of a membrana propria, in which the liver-cells lie. But this is only hypothesis, as he has not seen it. According to him, the latter fill up the membrana propria, for which reason the injecting matter penetrated to the periphery of the lobule, but not into the tubes themselves.

BACKER[4] even pretends to have seen this membrana propria, which by Kruckenberg and Theile is only hypothetically thought to exist. He describes it as a structureless membrane, covered by longitudinal fibres, which

[1] Gerlach's Gewebelehre, II. Auflage, p. 329.
[2] Ibid., p. 330.
[3] Ibid., p. 330.
[4] Ibid., p. 330.

only becomes invisible by drying, or when the cells (by imbibition of liquid) swell up, and thus lie close to the membrana propria.

REZIUS and WEJA[1] make statements to the same effect.

KRAUSE[2] declares that the bile-ducts take their starting-points from vesicles or true acini. These acini ought not to be confounded with the lobules of the liver; but they are, according to him, small round or slightly oval bodies, which by reflected light have a yellowish-gray appearance. They inclose six or eight hepatic cells, and form the greater part of the mass of the lobule. He also thinks that these small bodies, as they were not observed by others, had been looked upon as very large liver-cells.

LEREBOULLET,[3] in regard to the arrangement of the biliary cells, says:—

"The biliary cells are joined by their ends so as to form longitudinal series which converge towards the centre of the lobule. These longitudinal series are united by shorter transverse ones, so as to represent a network with meshes, polygonal or rounded, at the periphery of the lobule, and elongated towards its central part.

"Each thread of this network is double—that is, formed by two ranges of cells, which touch at their sides, and leave only a linear interval between them. But these two ranges of cells are only in juxtaposition, separating easily by the slightest traction.

"The cells which constitute the series are, on the contrary, adherent to each other. Hence we frequently see simple series of cells yet adherent after tearing a minute piece of the substance of the liver.

"These series or chains of cells do not form tubes, as was supposed by E. H. Weber. The cells which compose them do not open into each other, but are, on the contrary, perfectly distinct and independent.

"The network formed by the double ranges of cells pervades the whole thickness of the lobule from the perilobular vessels to the central one. Hence it is inaccurate to speak of the secretion taking place exclusively at the periphery of the lobule. The meshes of the network of cells are filled by the bloodvessels of the lobule.

"The double threads of the biliary network are probably surrounded by a proper membrane, which would constitute the basement membrane of the secretory tubes; but this is so adherent to the walls of the bloodvessels, as to render it impossible to prepare and demonstrate it in such a manner as to show that the included biliary cells are only epithelial. Therefore, in the natural state, these secretory tubes within the lobule would be full—that is, entirely occupied by the secretory cells; and hence their cavity is simply linear.

"When we succeed in throwing an injection into these biliary passages, the injected matter distends the linear intervals just described, compresses the cells, and gives the appearance of a rete of capillary ducts, which takes the place of the network formed by the double ranges of cells.

"The capillary biliary ducts of authors are, then, produced mechanically by the injection. These canaliculi have, indeed, no proper walls, the injected matter being in immediate contact with the secretory cells.

"The rest of the lobule is occupied by a vascular rete, formed by the por-

[1] Gerlach's Gewebelehre, II. Auflage, p. 330. [2] Ibid., p. 331.

[3] Medical Examiner, vol. x. (1854) N. S., p. 206 *et seq.*

tal vein and the radicals of the hepatic vein. The meshes of this network adapt themselves exactly to the threads of the biliary rete, and *vice versa*, so that the two are closely interlaced. The mean diameter of the threads forming the meshes, and of the meshes themselves, in either network, is 0.15 of a millimetre."

Further on, he states that "the biliary canals which have lobules, are always multiple. They arise from all points of the surface of the lobule, and after having frequently united with each other like the roots of a tree, leave the lobule and form one or more ducts, which, with the corresponding trunks of the portal vein and hepatic artery, are surrounded by a fibrous sheath, the capsule of Glisson."

LEIDY,[1] in his researches into the comparative structure of the liver, in speaking of the biliary tubes, says:—

"The lobules are composed of an intertexture of biliary tubes (*pori biliari*), and in the areolæ or interspaces of the network the bloodvessels ramify and form among themselves an intricate anastomosis, the whole being intimately connected together by a combination of white fibrous and yellow elastic tissue."

"In structure, the biliary tubes correspond with those of the intervertebrata, consisting of cylinders of basement-membrane containing numerous secreting cells, and the only difference exists in the arrangement; the free tubes of the lower animals in the vertebrata becoming anastomosed, or forming an intertexture. The tubuli vary, in size in an unimportant degree, in different animals, and also in the same animal, being generally from two to two and a half times the diameter of the secreting cells. The tubes of one lobule are distinct from those of the neighbouring lobuli, or only communicate indirectly by means of the trunks or hepatic ducts originating from the tubes and lying in the interspaces of the lobuli. The secreting cells are irregularly angular, or polygonal in form, from mutual pressure, and line the interior surface of the tubes. They vary in size in a moderate degree in different animals and also in the same animal, appearing to depend upon certain conditions of the animal and liver. The colour is light-yellowish, or brownish when in mass; the other and darker colours of the liver appearing to depend upon the blood in the organ. They contain a finely granular matter, oil-globules, a granular nucleus, and a transparent nucleolus."

BEALE,[2] one of the latest observers on the minute structure of the liver, and to whom I shall have occasion to refer again, maintains: That the smallest biliary ducts are directly continuous with the tubular network of basement-membrane in which the liver cells lie; for, in favourable specimens, injection, forced in from the duct, will pass into every part of the tubular network, even quite to the centre of the lobule. It is possible to inject the capillary network in the same preparation as that in which the ducts and cell containing network are injected.

KÖLLIKER[3] remarks, that in all his continued search, he has never dis-

[1] American Journal of the Med. Sciences. New Series. Vol. xv. p. 18.

[2] Beale, On the Anatomy of the Liver, 1856, p. 54.

[3] Kölliker's Handbuch der Gewebelehre des Menschen, 1852, p. 421.

tinctly observed a direct connection of the finest ducts with the network of hepatic cells, which, he continues, is not surprising in considering the softness of the parts in question; yet, leaves an opening in the minute anatomy of the liver which can scarcely be closed by hypotheses. As such, he offers the supposition that the finest ducts come in direct opposition with the columns of the network of hepatic cells, and thus have their orifices closed. He believes that such connections exist in no very great numbers at the periphery of the hepatic islets, which might be inferred from the scanty number of the finest branches of the hepatic duct.

The bile, he says, must be transmitted outwards from cell to cell, for the possibility of which process he refers to the physiology of vegetables.

Views, similar to those of Kölliker are entertained by C. HANDFIELD JONES.[1]

This observer, in regard to the excretory ducts, states: That the liver in all vertebrate animals may be regarded as consisting of a secreting parenchyma and excretory ducts. The size of the excretory apparatus bears only a small proportion to that of the secretory.

These two portions of the liver are not continuous with one another, but disposed simply in relation of juxtaposition.

The action of the liver seems to consist in the transmission of the bile as it is formed from cell to cell, till it arrives in the neighbourhood of the excretory ducts by which it is absorbed. This action is probably slow, and very liable to be interfered with, contrasting remarkably with that of the kidney, where a particular apparatus is added to insure completeness and rapidity of action.

In a second paper, written some years afterwards,[2] he says that farther observations confirm him still in the opinion he formerly expressed.

GERLACH,[3] from observations made on injected livers, comes to the conclusion that the intralobular ducts, after having arrived at the lobule, send off small branches, 0.002 to 0.004 of a millimetre in diameter, which, after having formed a free anastomosis at the periphery of the lobule, terminate in intercellular passages or free spaces, left between the cells. He remarks,[4] that the sudden transition of true tubes into intercellular passages, where the structureless membrane of the tubes ceases abruptly, is certainly a very uncommon phenomenon and altogether wanting of analogy. But the results of his numerous injections point it out so distinctly, and exclude every other explanation so perfectly, that he does not think proper to change his views. As a farther confirmation, he observed the termination of a small duct, belonging to the peripheral anastomosis, in a specimen of injected human liver. Here, he saw, with the greatest distinctness, that it terminated by an open mouth, in opposition to the views of H. Jones.

[1] Philosophical Transactions of the Royal Society of London, 1849, p. 132.
[2] Ibid., 1853, p. 2.
[3] Gerlach's Gewebelehre, II. Auflage, p. 333.
[4] Gerlach's Gewebelehre, II. Auflage, p. 336.

Since I commenced this article I have met with the valuable paper of M. NATALIS GUILLOT, "On the Structure of the Liver of Vertebrate Animals."[1] The results of his extensive researches, which were made ten years ago on injected specimens, are almost the same as those obtained by myself. The only difference is, that by means of superior accessory instruments my conclusions were drawn not only from observations on well injected specimens, but also from the fragments of fresh livers from divers animals.

Guillot, in speaking of the termination of the hepatic duct, says:—

"After having followed the ramifications of the portal vein and the hepatic artery, and having surrounded them with numerous loops, and after having connected themselves a thousand times by the finest anastomoses, the biliary vessels (ducts) are replaced, or, in other words, continued by an *order of canals*, the traces of which may be recognized in the middle of the mass of hepatic cells.

"It is, to the middle of the islets,[2] surrounded by the anastomoses of the capillaries of the blood that this collection (ensemble) of biliary canals may be seen; they can be traced to this place, not only in fishes, reptiles, and birds, but also in mammiferous animals, and in the liver of man.

"They cannot be distinguished without first being made visible by means of injection. Without this indispensable precaution, the finest slices of the liver of fish, bird, or mammiferous animal, will give no evidence of the existence of any sort of regular canals."[3]

[1] Annales des Sciences Naturelles. Troisième série. Zoologie. Tome ix. p. 163.

[2] Groups of six or eight cells contained within the meshes of the capillary blood-vessels, but connected with each other.

[3] As I consider the observations of Guillot important to the confirmation of my own, I will quote his own words: *Annales des Sciences Naturelles*, p. 132.

"Ayant cherché à savoir si cette manière de voir était exacte, elle m'a, au contraire, semblé fort douteuse. Quelsqu' aient été les animaux soumis à mes observations, nulle part l'agrégation de ces particules (cells) ne m'a paru être régulière.

Lorsque les particules du foie des animaux vertébrés sont réunies les unes auprès des autres, l'irrégularité des points de contact, par lesquels elles se touchent, apparaît avec une grande évidence. On est ensuite frappé du caractère singulier des fragments observés, lorsqu'on a fait aucun effort capable des dissocier les éléments qui les composent, et de les éloigner les uns des autres. Ils forment alors une agrégation tellemens serrées, qu'il paraît impossible à la bile ou au sang de trouver un passage entre ces particules.

Cette apparance est commune à tous les animaux.

Ceux d'entre eux qui ont péris par suite d'une hémorrhagie offrent au plus haut degrée cette contiguïté des particules du foie; chez ceux, au contraire, dont la mort a été lente, il reste encore une assez grande quantité de sang dans l'organe pour donner à la matière des caractères entièrement opposées. Certain details apparaissent alors, obscure encore, il est vrai, mais trop intéressants pour ne pas meriter une serieuse attention.

Dans ces organes pénétrés d'une certain quantité de sang, ce liquide est encore contenu dans les canaux, au travers desquels il circulait pendant la vie, et c'est

It will be seen from the above, that the views of the majority of observers have been based mainly on hypotheses or analogy. I shall, therefore, be very guarded in expressing any opinion not founded on observation, and shall leave the rest to the judgment of men more experienced on the subject than myself.

While, with Guillot, Gerlach, Beale, and others, I consider a good injection absolutely necessary for a thorough investigation of the structure of the liver, yet I do not think that we should confine ourselves altogether to this mode of investigation. We ought also assiduously to examine the tissue of the organ in its fresh state; but if the choice were left to me between the two modes of investigation, I would unhesitatingly give the preference to the former. We are surely better enabled to distinguish the relationship of the vessels, canals, &c., in a thin, transparent slice of the organ, when they are well filled with colouring matter, than on a fragment of soft tissue which mostly shows only a confused mass of ducts, capillaries, cells, fibrous tissue, &c. Although after long practice and study we succeed in distinguishing readily a capillary, duct, &c., yet it is extremely difficult, after these delicate

precisement dans les endroits où les globules sanguins séjournent que les particules du foie cessent de se toucher.

Par un examen attentif des parties où l'on observe les globules sanguins, on peut déjà être conduit à distinguer, certains canaux régulièrement disposés dans l'épaisseur de la matière.

Les traces régulières de ces canaux n'indiquent-elles pas déjà que les particules du foie, appliquées les unes contre les autres dans quelques circonstances sont forcées, dans d'autres cas, de s'éloigner de celles qui les toucheraient si l'organe était privé de sang?

Négligeant maintenant d'autres considerations, je ne m'attacherai qu'à faire remarquer l'evidence avec laquelle ces canaux apparaissent, lorsqu'on examine, même sans de très forts grossisements, des parcelles de foie injectées avec l'eau colorée, l'essence de térébenthine ou même le mercure. Ils effacent, et disparaissent dès ques ces liquides se sont écoulées, et les particules redeviennent alors comme auparavant exactement appliquées les unes sur les autres. C'est principalement à ces études que sont utiles les injections de matières diffluentes.

P. 163. Après avoir suivi les ramifications de la veine porte et de l'artère, les avoir entourées d'anses numbreuses, après être unies mille fois par des anastomoses de plus en plus fines, les vaisseaux biliares sont remplacées ou mieux continuées par un ordre de canaux dont on reconnaît les traces au milieu de la masse des particules du foie.

C'est jusqu'au milieu des îlots entourées par les anastomoses des canaux sanguins que l'on decouvre cet ensemble de canaux biliaires; on peut les suivre jusqu'à cet endroit non seulement dans les Poissons, les Reptiles et les Oiseaux, mais encore dans les animaux mammifères et sur le foie de l'Homme.

On ne peut les distinguer sans les avoir mis en evidence à l'aide d'une injection préalable. Sans cette précaution indispensable, les tranches les plus minces du foie d'un Poisson, d'un Oiseau ou d'un animal mammifère, ne laisseraient supçouner l'existence d'aucune espèce de canal régulier. Les particules du foie serraient alors immédiatement appliquées les unes sur les autres."

parts have been roughly torn and displaced by means of needles, to detect the relative position they held before their separation.

As a good, minute injection of the organ is so important for its investigation, it may be proper here to make a few remarks on this subject.

If I may judge from the expressions of different authors, it seems that minute injections have often been undervalued as a means of microscopic investigation. The reason for it is very obvious. To acquire facility in making injections requires much practice, and the expenditure of more time than most persons can devote to it. Besides this, it is a tedious and vexatious process. Frequently a small vessel will rupture, and the colouring material be thrown over the person of the operator. It is also expensive, as a great deal of material is wasted before experience enough is acquired to have the process perfectly under control. Many disappointments are met with; and if the injector be not possessed of a good share of perseverance, he will certainly become discouraged and give up the matter. Further, to be a skilful injector requires not only some mechanical skill and judgment, but also manual dexterity; which, unfortunately, all men of science do not possess. I have frequently seen profound students using their fingers as awkwardly as a child. Experience, and manual dexterity, are therefore required to make good injections; and I have no doubt that those anatomists renowned for their beautiful injections, as Bèrres, Hyrtl, and others, possessed both.

To make a good injection, the pressure should be applied very gradually. In injecting a liver, I am in the habit of first injecting the duct, then the artery, and lastly the veins. With one exception, I have always injected the entire liver, although small portions may be used. In order to inject the organ perfectly, it should be healthy and uninjured.

The material to be injected is a most important consideration. I believe that gelatine has been a favourite vehicle of many anatomists for the conveyance of the colouring matter. In former experiments I have frequently used it; but there are inconveniences attending it, and now I never employ it, except for special objects. For instance, the organ to be injected must be kept at the same degree of temperature required for retaining the injecting matter in a fluid state; besides this, the colours cannot be readily mixed with it, as few of them are soluble in water; it is also very inconvenient to strain the material.

Ether I have found to be the most easily managed liquid. It is one of the most penetrating of fluids, but by itself is of too low a specific gravity to carry a heavy substance like vermilion; therefore it is necessary to give it a body. For this purpose the resins, wax, fats, &c., may be used, but the best material is *Canada balsam;* this is an excellent vehicle for carrying the colouring matter into the minute biliary vessels. I am unable to state the precise density which answers best. My mode of determining this is by letting some drops of it fall on a piece of glass; it ought to evaporate in about

half a minute, and leave a body which may be tested by scratching it with a needle. After the solution is brought to its proper density, it must be filtered through good filtering paper, for any liquid thin enough to pass the paper will also penetrate into the capillaries. Besides the Canada balsam, I use wax. The density of this solution is regulated by the filtering paper; if it is too dense, the superfluous wax remains behind. This solution always looks clear when well filtered. If we use the solution of Canada balsam alone for the injections of tissues to be dried and then cut in thin, transparent slices, they become too hard; to avoid this, I usually mix the solution of balsam and that of wax, in equal proportions, as the wax gives softness and pliability to the preparation. But for the injection of the biliary ducts I use the solution of Canada balsam alone, as the wax is granular.

Another important point in regard to the injecting matter is the consideration of the colour to be mixed with it. The finest colours are those ground up with linseed oil, and used by artists. By the process of trituration which they undergo they are thoroughly mixed with the oil, which is very soluble in ether.

My only method of testing the density of the coloured liquid is by slightly shaking the bottle in which it is contained, and then observing whether the colour is dense enough to remain upon the glass for a few seconds, before falling to the bottom.

For the injection of the biliary ducts I use only half the amount of colouring matter for filling the small ramifications, and afterwards inject a denser liquid, which, by pressing upon the former, forces it into the smaller passages. The colour I prefer for the ducts is chrome-yellow. After a little practice the operator becomes familiar with these particulars, and distinguishes them without losing much time in weighing and measuring.

After a liver has been well injected, it should be dried in the air for three or four fine days, so that the ether may evaporate, then be cut into slices 1 or $1\frac{1}{2}$ inch thick. Without this precaution the peritoneal covering prevents the evaporation of the watery parts, and thus a longer time is required for drying.

In regard to the mode of making the best sections, I refer to the description of the *apparatus for making microscopic sections*. The sections, if well made, must be transparent. They should be examined in some liquid, as water, glycerine, &c.

The tissue of the liver is no more altered by the action of ether than by that of alcohol. The former coagulates the albumen, giving a more granular appearance to the cells. In fine sections the nucleus is difficult to recognize, but I have sometimes seen it. The watery parts of the tissue lost in the process of drying, are regained when the tissue is immersed in liquid for a short time, so that it is as good for examination afterwards as before. Some may object to the examination of specimens which have

been dried; but the relationship of the structure is not altered. If the cell loses its watery parts, the capillary or the duct does so likewise; both will imbibe in like proportion, the amount of colouring matter remaining the same.

Having now given the necessary directions for the injection of the organ, I shall proceed to the consideration of the anatomy of the hepatic lobule.

The views I had been taught, and which I still entertained when commencing these investigations, were, that the cells lay within a network of tubes of basement membrane, continuous with the branches of the duct; and, reasoning by analogy, these views seemed to me probable, for I could not believe that the bile was transmitted from cell to cell until it reached the open or closed mouth of the branches of the hepatic duct.

When I examined specimens of the first liver injected by me, which was that of a cat, I noticed a reticular arrangement of the colour (chrome-yellow) which I had thrown into the hepatic duct. This examination was merely a superficial one, and made on opaque pieces by reflected light. Although my object had been to inject the network of tubes of basement membrane, yet I was much surprised at my early success, and the idea suggested itself that a duct had been ruptured and the colour had entered into the bloodvessels. After some reflection, I saw the improbability of the liquid having ruptured a duct from within, and then perforating the wall of a bloodvessel from without. In several other injections I obtained the same results; but all these examinations were made with reflected light, for I had not yet made a thorough examination of transparent sections with transmitted light. I also examined fragments of fresh livers; and yet, with all my constant efforts, I could never discover the slightest evidence of the existence of the tube of basement membrane. The rows of cells I always met with seemed to be held in close apposition by some invisible agent. I saw capillaries with their nuclei, ducts lined by an epithelium, fibrous tissue, &c., but no membrana propria.

I met with a similar disappointment in examining fine sections. The rete injected had not the appearance of one formed by tubes large enough to contain hepatic cells. I noticed, too, that this injected rete corresponded mostly with the course of the capillaries, only crossing the latter here and there; which observation led me to think that this rete was an independent one.

Further observations on injected and fresh specimens of liver have confirmed opinions which I will state in substance before proceeding to details, viz: *Two capillary networks, each independent of the other, exist in the lobule of the liver; the one, commencing at the periphery of the lobule, from the smallest branches of the portal vein and hepatic artery, and ending in the centre in those of the hepatic vein, is destined for the circulation of the blood brought there by the portal vein and hepatic artery; the other, commencing independently in the centre of the lobule, near the*

intralobular vein (branch of the hepatic vein), and ending in the smallest branches of the hepatic duct, is most probably destined to carry off the secretion of the cells. The cells lie within the meshes of these two networks, but seem to be especially held in their position by their adhesion to the network destined for the secretion.

These fine biliary vessels are in reality *biliary capillaries;* but, for the sake of contradistinction from the capillaries that carry blood, I shall call them *biliary tubules,* until my observations have been confirmed by others, and a better name proposed.

The observations made on injected specimens shall be first considered.

In sheep, as in man, the lobules of the liver have no definite borders, hence it is difficult to say where one ceases and the other commences; we can only judge by the relation and proximity of the branches of the different vessels. The intralobular branch of the hepatic vein runs at a right angle with the portal vein, which is accompanied very closely by the hepatic duct. The portal vein sends off branches which ultimately ramify into the capillary system; similar branches of the hepatic duct pass into a system of their own, the boundaries of which extend to the intralobular vein. The capillaries of the duct (biliary tubules) are mostly seen lying alongside of those of the portal vein, except when they cross each other to form an interlacement; the cells lie in the interspaces.

Pl. I. Fig. 1, which represents a thin transparent section of a part of the lobule of the sheep (viewed by transmitted light), conveys a good idea of the relationship existing between the branches and capillaries of the portal vein and those of the duct. Here, we see at (*a*) the transverse section of a branch of the former, and at (*b*) one of the latter; both send off smaller branches, and after having become capillaries, interlace themselves; between and around the two vessels the fibrous tissue can be seen, belonging to the capsule of Glisson.

In the liver of the hog (Pl. I. Fig. 2) each lobule is enveloped by a capsule of fibrous tissue; which by some anatomists is supposed to be a continuation of the capsule of Glisson. The branches of the *portal vein,* after entering between the lobule, divide into numerous other smaller ones, which surround the capsule; these again give off shorter ones, which penetrate the capsule to form the interior capillary network. The branches of the *duct* lie close to those of the portal vein, and are given off exactly in the same manner. The *hepatic artery* also closely follows the vein and surrounds it with a network of its branches; its finest ramifications, after having penetrated the capsule, are blended with the blood carrying capillaries of the lobule, and thus the blood of both vessels is mixed within the latter. I have often seen the capillary network, of entire lobules, filled with the colour *injected through the artery.*

In the liver of the sheep I have noticed very extensive anastomoses of the small branches of the duct around the branches of the portal vein.

It is believed by some, that the meshes of the capillaries are more oblong near the intralobular vein than the portal branches, but I find little difference between them; and in some instances, in the liver of the sheep, I have observed directly the reverse. The capillary network seems to be formed (at least in the hog) by more or less strait vessels, radiating from the intralobular vein as a common centre towards the periphery of the lobule; these vessels are connected with each other by shorter transverse branches, and thus the rete is formed. In fresh specimens I have often observed capillary vessels as long as six or eight liver cells with the remnants of the broken transverse branches adhering to them. The cells I believe to be arranged in the same manner, that is, generally in single rows, radiating from the centre and connected by shorter ones. Of course, these radiating vessels and rows of cells, arising from the periphery, cannot all run to the centre, but the greater number of them are lost between the others.

In fine transparent sections I have observed a tendency to split in the lobules of the liver of the hog; usually this commences at the centre, extending towards the periphery, though it sometimes occurs from one periphery to the other, through a small portion of the lobule. Searching for the cause of this in entire lobules, I found it to be fine transparent lines, bounded by fine double contours, and running mostly from the centre of the lobule towards a branch of the portal vein; other finer lines, with the same contours, are seen extending into them; the course of both are usually serpentine. The capillaries can be seen running across these lines. This has been observed in hundreds of lobules, for my apparatus enables me to make sections, containing about eighty lobules, with great rapidity. In tracing one of these lines, I observed in one instance that it passed from one lobule to another through the fibrous tissue of the capsule; in some cases more than one is seen in the same lobule. (In examining sections of the liver of sheep, treated with a weak solution of potassa, which renders them transparent, I observed empty vessels running towards the vein. At first I supposed them to be lymphatics, until I noticed others as large as the finer branches of the portal vein, which made me suspect them to be uninjected vessels.)

That the above-mentioned fine transparent lines in the hepatic lobule of the hog are not nerve fibres, seems evident to me, since the course of a nerve is more wavy than these lines. Are they then the ultimate branches of the *lymphatics* which have not yet been observed? I merely mention this for the purpose of directing the attention of other observers, not having examined it sufficiently to form an opinion myself.

The *biliary tubules* can also be recognized in specimens in which only the capillaries have been injected. If such a section is treated with a weak solution of potassa, which makes it expand, fragments of fine vessels can be seen at the sides of the capillaries, often traversing the latter. Such a view is represented in Pl. I. Fig. 4. If these double contours extended entirely

along the sides of the capillaries, they might be taken for their walls; as it is, I suppose them to be nothing but the fragments of uninjected biliary tubules, especially as we find them here and there crossing the capillaries. The dark places in the vessels are caused by the presence of colouring matter.

I have already advocated the mode of investigation by injection. But as some may consider the injected biliary tubules as nothing more than extravasations between the cells, I will adduce further considerations in support of my views.

An extravasation is very readily distinguished from a perfect injection by one accustomed to the examination of minute injections. It is an infiltration into the tissue, caused by the rupture of one or more of the capillaries, and looks very irregular. The interspaces between the capillaries are filled up by the colouring matter, if the extravasation has taken place to any extent; the material sometimes forms small curves, but these can never be mistaken for a regular arrangement of vessels; Pl. II. Fig. 9 represents the aspect of a duct whose branches are ruptured and the colour extravasated. Every one can recognize the very great contrast between it and Fig. 3, Pl. I., which represents a part of a thin section of the liver of the hog, in which only the duct has been injected. Here the regular arrangement of the injected *biliary tubules* is too evident and striking to be mistaken for an extravasation. If the extravasation is slight, it has an aspect somewhat like Fig. 8, Pl. II. This has probably been the case with *Gerlach's* injections of the ducts, which led him to think that these canals had no walls of their own, but were intercellular spaces. If the drawing, accompanying the extract from *Lereboullet's* researches on the intimate structure of the liver, in the *Medical Examiner*, be a true copy, I can only consider it the representation of a complete extravasation into the interspaces of the capillary network of the lobule. The injected specimens examined by C. H. Jones seem also to have been imperfect. In the injections of the livers of the pig, of which he speaks,[1] the fault, most probably, was in the material, which consisted either of a bad vehicle contained with too much colouring matter, preventing it from penetrating into the biliary tubules. The trials which he afterwards made[2] on only two livers with the acetate of lead, were not sufficient for drawing any conclusion. The acetate of lead is not a proper material for injections: it formed, as he says, a precipitate with the albuminous plasma between the cells, but only after having ruptured the biliary tubules. The injecting material should be as neutral as possible.

Very slight pressure is required for the injection of the biliary tubules; less than that for injection of the bloodvessels.

In regard to the theory of the cell containing network of tubes of base-

[1] Phil. Trans., 1849, p. 125.

[2] Ib., 1853, p. 2.

ment membrane, I would observe that if such an arrangement existed in the hepatic lobule, and the tubes of this were injected, a section of it would give the appearance represented in diagram Pl. II. Fig. 7. The injected rete, instead of being alongside the capillaries, would occupy the middle of the meshes and send little branches for a short distance between the cells. Besides this, there is another very important fact, which seems to have been entirely overlooked; this is in regard to measurement. The diameter of a cell is twice or three times that of a capillary. Now, the interspaces of the capillaries in a thin section of injected liver are not large enough to admit more than one cell; again, the cells in fresh specimens are mostly met with, arranged in single rows; we seldom see them double. It might be said that the capillaries are distended by the colouring matter; but when this is the case, the interspaces will be seen almost obliterated by the distension of the vessels. If, on the other hand, the capillaries are but moderately filled, it might be said that the cells collapse and shrink away. This view, however, cannot be sustained, because if the cells shrink away, the ethereal solution in the capillaries will evaporate and leave nothing behind but the colouring matter and other solid elements of the solution. This can be well seen in Pl. I. Fig. 4, where both capillaries and cells have expanded again by the action of the potassa; the colouring matter not being sufficient to fill up the vessels. Pl. I. Fig. 6, which represents the outlines of the capillaries of a thin section, treated by a weak solution of potassa, shows this also. Pl. I. Fig. 5 represents two cells from the same piece; they overlap each other, and are too large to be admitted through some of the meshes.

Additional confirmation of the views above expressed, have been obtained by observations on fragments of the fresh liver, in which I demonstrated the existence of the *biliary tubules* very satisfactorily to myself in different modes, as follows:—

When we take a small fragment of liver, tear and separate its constituents on a glass slide, and then place it under the microscope for examination, it is only by accident we meet with a favourable exposition of capillaries, ducts, &c.; and, even then, it is no easy matter to observe in this confused mass, the true relationship of the elements of which it is composed. But if we can separate these parts by means of fine needles, and in the mean time observe all the details of the process, points are brought into view, which before were hidden to our closest observations.

The Microscopic Dissector, I invented for this purpose, has enabled me to make such observations. (See description of this instrument.)

For this purpose the liver of the hog is especially suitable. In cutting through one of its lobules, and taking a small fragment from its contents, we are certain not to have fibrous tissue mixed with the cells and capillaries, for the capsule of Glisson does not extend into the interior of the lobule. To corroborate this, I will cite the opinion of Beale, who is one

of the latest writers on this subject. In speaking of the capsule of Glisson, he says :[1]—

"*Most anatomists have failed to demonstrate a trace of areolar tissue within the lobules of the liver. Occasionally a few fibres of a structure like fibrous tissue, undoubtedly, is observed in uninjected specimens; but such an appearance is produced by physical alterations of the structures in the lobule, in the preparation of the specimen, or it is the result of disease. In the lobules of the livers of all animals which have fallen under my notice, it was impossible to demonstrate any fibrous structure whatever.*

"*Even in the interlobular fissures of the human liver, and of others allied to it in structure, I have been unable to detect any fibrous structure.* BOWMAN, HENLE, *and* VOGEL *have altogether failed to detect any areolar tissue in this situation in the human liver.*"

In examining such fragments, taken from the lobule of the hog, we often meet with rows of cells, either floating free or still adhering at one extremity to the fragment. In taking hold of the extremities by means of the needles of the dissector, and then separating them in a very slight degree, the row of cells will first become more straightened, and afterwards one or two of them usually become elongated; if the needles are still more separated (but in the slightest possible degree), the separation of those two cells may be observed, and one or two *tubular elements* will appear between them. In Pl. II. Figs. 10 and 11, this appearance is represented. These tubular elements I believe to be the *biliary tubules;* their diameter is $\frac{1}{1650}$ of an inch. Little dilations are seen here and there in their course, which appear very distinct after the treatment with alcohol and other similar reagents, which often gives them the appearance of a row of beads. The remnants of their branches are almost always still adhering; very often we meet with the entire branches, representing meshes from which the cells have escaped. Pl. II. Fig. 12 is an exact representation of a good specimen. They may be stretched to a great extent without breaking, and are very distensible, which is proved by injection. Unlike the fibrils of connective tissue, these elements do not swell up when treated with acetic acid; furthermore, their contours are not sharp and distinct like those of connective tissue, but are softer and often irregular.

It has already been mentioned that the existence of connective tissue in the lobule of the liver, has been denied by most anatomists. If then these opinions be correct, the question, what are *these elements*? remains open for discussion. The only answer I can give is, that they are the *biliary tubules*, which I injected not merely in a few but in numerous livers.

In the liver of the ox I have, in some instances, by means of the dissector, isolated one of the smaller branches of the duct, $\frac{1}{3300}$ of an inch in diameter, with the remnants of biliary tubules still adhering.

Pl. II. Fig. 13 represents a dissection of a fragment of the liver of the hog, made with the Microscopic Dissector. The outlines of this drawing are accurately copied from the dissection, but for the sake of distinctness

[1] Beale on the Anatomy of the Liver, p. 19.

I have altered the shading. As the constituents of the tissue are transparent to some extent, some of the capillaries lying either above or below, some cells are only distinctly demonstrated by observing closely the changes of their position, produced by the movements of the needles; the better to distinguish them they are left light. This manœuvre is one of the greatest advantages derived from the *Microscopic Dissector*.

But it is not only by injection or by means of dissection that the *biliary tubules* can be demonstrated. They can also be seen without any previous preparation with a high power. If a fragment from the interior of the lobules of the liver of the hog be taken, and after having been treated with ether (to get rid of the oil), it is examined with compression, a network of light streaks is seen, which does *not* correspond with the outlines of the cells, as might be supposed; this is the network of the *biliary tubules;* the capillaries with their nuclei can also be recognized in such a preparation. Even in fragments, consisting only of 4–8 cells, the tubules can be seen.

In taking a fragment (which has been treated with ether and then compressed) and tearing it slightly without separating it, we often observe in the fissures, produced by the separation, the tubules running from one margin to the other; after they have once been demonstrated satisfactorily, they can be recognized under almost any circumstances.

EXPLANATION OF THE PLATES.—PLATE I. *Fig.* 1. A thin section of a portion of a hepatic lobule of the sheep. *a*. Transverse section of a branch of the portal vein; two smaller branches are given off, which terminate in the capillary system. *b*. Transverse section of a branch of the hepatic duct; its finest branches are seen terminating in the network of biliary tubules. The fibrils of the capsule of Glisson are seen between the vessels; the interspaces of the capillaries are filled up by the cells. Magnified 172 diameters.

Fig. 2. A portion of a hepatic lobule of the hog. *a*, *a*. Transverse section of branches of the portal vein, sending off their branches to ramify around the lobule; they are enveloped by the capsule of Glisson. Shorter and smaller branches are seen to penetrate the capsule, terminating in the capillary network. *b*, *b*. Transverse section of branches of the duct, which are distributed in the same manner as those of the portal vein, terminating in a capillary system of their own. *c*. Transverse section of an intralobular vein (branch of the hepatic vein). *d*. Hepatic artery. *e*. Fibrils of the tissue of the capsule. The cells are seen in the interspaces of the capillaries. Magnified 172 diameters.

Fig. 3. A thin section of the hepatic lobule of the hog, in which the duct alone is injected. *a*. Branch of the hepatic duct, terminating in the network of biliary tubules. *b*. Fibrous tissue of the capsule. The cells are seen in the interspaces. Magnified 92 diameters.

Fig. 4. A thin section of the hepatic lobule of the hog, treated with a weak solution of potassa. *a*, *a*, *a*. Capillaries. *b*, *b*. Remnants of the uninjected biliary tubules. The dark places are caused by the colouring matter in the vessels. Magnified 400 diameters.

Fig. 1.

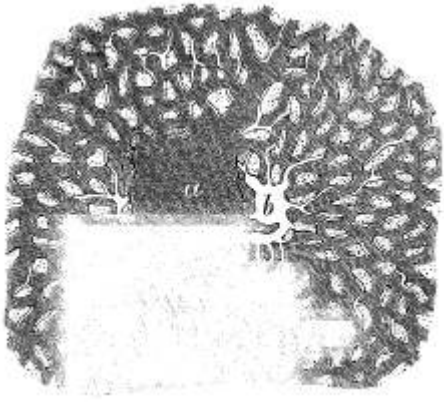


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 6.

Fig. 5.

Fig. 7.

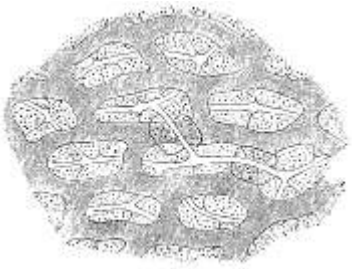


Fig. 8.

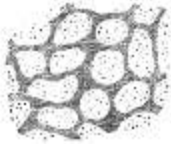


Fig. 9.

Fig. 10.

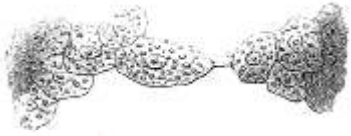


Fig. 11.

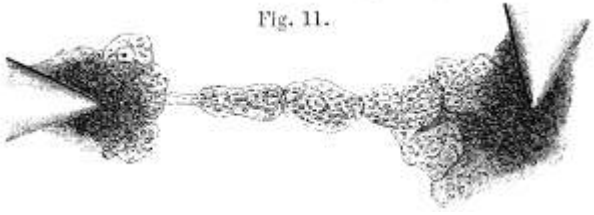


Fig. 12.

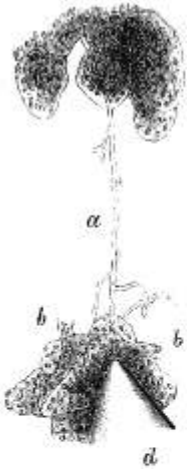


Fig. 13.

Fig. 5. Two cells from the section of

Fig. 6, which represents the outlines of the capillaries in a section treated with potassa. Magnified 266 diameters.

PLATE II. *Fig.* 7. Diagram of an imaginary section of injected liver, as it would look in case of the cells laying in tubes of basement membrane.

Fig. 8. Diagram of a moderate extravasation.

Fig. 9. Diagram of a complete extravasation.

Figs. 10 *and* 11. Liver-cells at the moment of separation, showing the *biliary tubules* between them. 10. Magnified 266 diameters. 11. Magnified 400 diameters.

Fig. 12. *a*. Biliary tubule, with branches still adhering. *b*. Capillaries. *c*. Cells. *d*. Point of a needle of the Microscopic Dissector. Magnified 400 diameters.

Fig. 13. Dissection made with the Microscopic Dissector. *a*. Biliary tubules. *b*. Capillaries. *c*. Cells. *d*. Points of the needles. For the sake of distinction the capillaries are left light. Magnified 400 diameters.

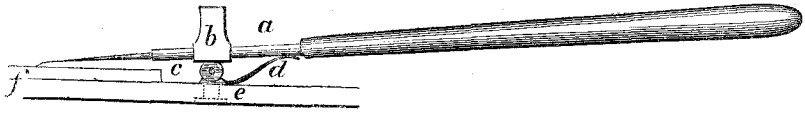
The Microscopic Needle Holder.—About eighteen months ago, when engaged in microscopical researches on the construction of the primitive nerve-fibre, I contrived an instrument which, by serving me as a support for my dissecting needles, enabled me to separate and stretch tissues under the microscope, while, at the same time, my observations with a comparatively high power would be continued. This instrument answered an excellent purpose, by enabling me to put single nerve-fibres on the stretch, but was insufficient for the slow and accurate movement required in some histological investigations. To accomplish this latter I was led to contrive a more complicated instrument, of which I shall speak hereafter. As the construction of the former is very simple, and is thus brought within the reach of every one, engaged in histological studies, I consider it worthy of description.

Figs. 14 and 15 are representations of it, with a slight modification.

It consists of three parts, viz., a needle (*a*) with a handle made of light material; a lever (*b*, *c*, *d*), movable in different directions, to hold the needle, and a brass plate (*e*) in which the lever turns like a pivot; the latter also supports the glass slide (*f*) upon which the preparation is to be placed.

A portion of the needle (Fig. 14, *a*) is cylindrical in order to move very

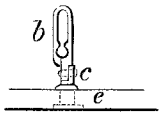
Fig. 14.



smoothly and evenly in the lever (*b*); the forward, backward, and rotary movements being thus effected. The needle part should of course be very fine at its points, and slightly bent, to facilitate dissection. The lever

consists also of two parts. The upper (*b*) acts like a spring, to hold the needle moderately tight in its place, though loose enough to allow the rotary and sliding motions of the cylinder to be effected with ease. In the lower half of this part a round orifice (Fig. 15, *b*), for the reception of the cylinder of the needle, is seen; this orifice is open above and below; the upper part being wider than below, so as to preserve the curved point of the needle from injury in passing through. The lower part of the lever serves as a pivot in performing the rotary motion in the brass plate (*e*). Both parts connected form a hinge-joint (*c*), by means of which the elevation and depression of the point of the needle is effected. Connected with one side of the lower part of the lever is a little feeble spring (Fig. 14, *d*), which, by pressing the handle of the needle upward, keeps the point constantly upon the glass to maintain its hold on the tissue to be dissected, thus allowing the operator to remove his hands from the instrument without disturbing the preparation. This spring should not be strong enough to injure the delicate point of the needle. The preparation may be held down to the glass by a lever with spring like that of the Microscopic Dissector. (Figs. 16 and 19, *b*.)

Fig. 15.



It appears from the works on the microscope and its accessory instruments, among which we may mention those of Quekett and Carpenter, that microscopic dissections had been previously carried on by means of fine needles attached to a handle, and managed only by the hand. The dissections made in this manner could only be performed under a very low power, and would necessarily be very coarse; for the slightest movement of the hand, scarcely observable by the unaided eye, would (under a high microscopic power) make the needle sweep almost over the whole field.

In former investigations it had been customary to separate the tissues finely before examination. But this is only blind dissection, since we are unable by this process to observe the changes going on *during* separation and destruction, and only observe their appearance after the minute structures have been partially destroyed.

To obviate these difficulties, and to carry on my microscopic observations with more accuracy, I contrived an instrument, which I have now in use, and shall now describe.

The Microscopic Dissector.—In the construction of this instrument, the principal object I had in view was, to be enabled to make the slightest motion of microscopic needles, knives, or scissors, in different directions. This can only be accomplished by the screw movement, which also keeps the instruments stationary, and thus gives freedom to the hands for changing object glasses or eye pieces, or applying reagents, while the preparation is undisturbed.

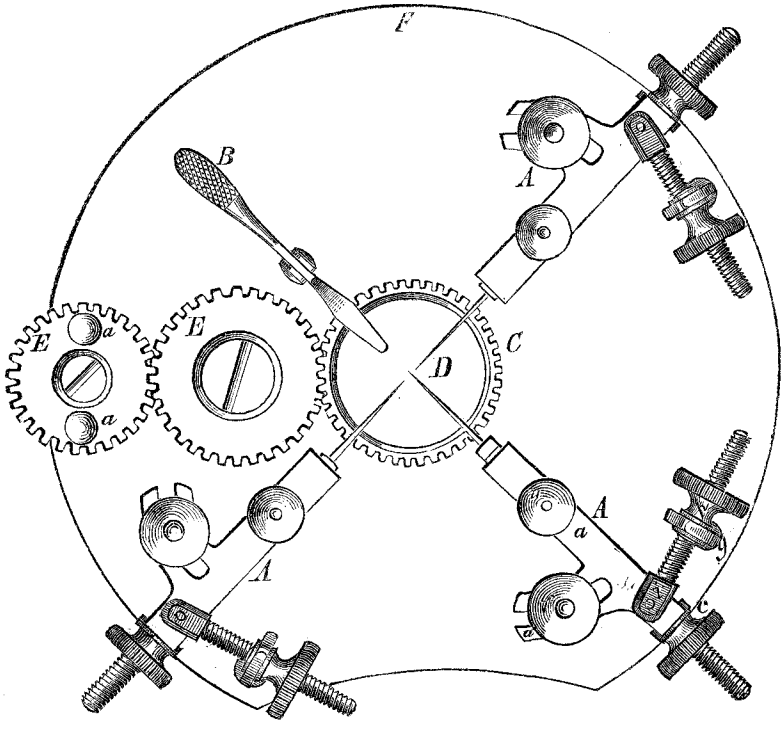
The instrument consists of three levers (*A*, *A*, *A*) to hold the needles,

one lever (*B*) with spring to fix the preparation to the glass, a brass ring (*C*) with a shoulder for the glass (*D*) to rest upon, and two cog-wheels to rotate it. These several pieces are connected with a brass plate (*F*), upon which they move, and the form and size of which will vary, according to the stage of any particular microscope.

In order to simplify the description of this complicated instrument, I shall speak of these different pieces separately.

The *lever* (*A*, Figs. 16 and 17) is destined to hold the instruments, and,

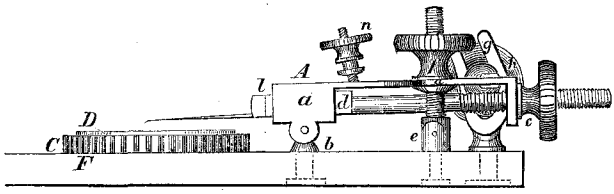
Fig. 16.



therefore, must have motion in all directions. Like the Microscopic Needle Holder, it consists of two principal parts (Fig. 17, *a*, *b*), which together form a joint by which the upward and downward motion is effected; the lower one (*b*) rotates in the brass plate (*F*) by which the horizontal movement is accomplished. The longer extremity of the upper part (*a*) is bent in a right angle, and has a round hole in which a nut (Figs. 16, 17, and 18, *c*) moves. To keep this nut in its place, it has a small notch, which by means of a pin secures the former and prevents it working out. The shorter extremity, or body part (Fig. 17, *a*), has a square hole, in which the piece (Fig.

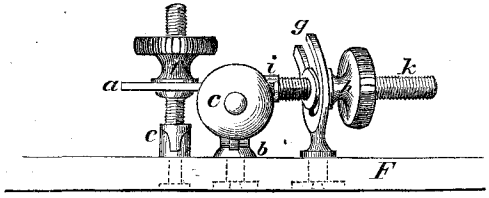
17, *d*), to which the different instruments are screwed, moves forward and backward. One extremity of this piece (*d*) is square, to prevent it from turn-

Fig. 17.



ing, and must work very nicely in the square hole of the lever, for the accurate movements of the point of the needle depend to a great extent upon the

Fig. 18.

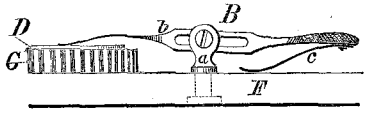


precision of this sliding motion. The other extremity has a fine thread cut on and passes through the nut (*c*), and thus the screw-movement for effecting the advance or retreat of the instrument is established. To produce the up and down movements of the lever, we have another piece (Figs. 17 and 18, *e*) added, which has a joint at its lower part; the upper part has a thread cut on, which forms a screw-movement with the nut (Figs. 16, 17, and 18, *f*). This nut has a notch on one end, in which a lateral prolongation of the lever (*a*) slides (Figs. 16 and 17, *a*, *f*, and Fig. 18, *e*, *a*, *f*, show this plainly). It will be seen that the nut (*f*) being held to the lateral prolongation of the lever (*a*) by means of the notch, will produce the upward and downward movements of the instrument, when turned on the screw of the piece (*e*), as the latter is attached to the brass plate. A third piece is added to effect a sideward movement; this is best seen in Fig. 18, where it is marked by the letter *g*. The lower part of this piece rotates in the brass plate (*F*); the upper one is split like a fork, in which the nut (*h*) turns and slides freely up and down, according to the upward and downward motion of the lever with which it is connected by the piece (*i*). The one extremity of the latter (*i*) is connected by a pin with the longer extremity of the lever (*a*), and thus forms a hinge-joint, while the rest (*k*) has a thread cut on, with which the nut (*h*) forms a screw-movement. If we now look at the lever (*A*) in Fig. 16, we can readily perceive how, by turning the nut (*h*) in one or the other direction,

the distance between the longer extremity (*a*) of the lever is either increased or diminished, and consequently the point of the needle moved toward one or the other side.

The *lever* (*B*) for holding the preparation is represented in Figs. 16 and 19. It consists of two parts; the lower one (*a*) rotates in the brass plate (*F*); the upper one forms the true lever; it has an oblong opening in the middle, which slides along a screw connected to the former, serving as a fulcrum. One extremity is thin like a spring, and is intended to hold the preparation to the glass, the other has a spring attached to it. By this arrangement the point of the lever can reach the preparation at any place of the glass.

Fig. 19.



The *brass ring* (*C*) has a shoulder for the glass to rest on; its circumference has teeth to form a cog-wheel, and to be thus revolved by the two other cog-wheels (*E*, *E*).

The *glass* (*D*) is a simple round glass plate, which rests on the shoulder of the brass ring (*C*). The glass plate fits also to a similar ring of my compressor; so that a preparation previously dissected may be compressed without disturbance, by simply transferring the glass slide on which it rests.

The *cog-wheels* (*E*, *E*) are simply held down to the brass plate (*F*) by screws with a large head, the one has two buttons (Fig. 16, *a*, *a*) to turn it.

The *brass plate* (*F*) has been mentioned already; it may be attached to the stage by means of small clamps.

Besides the dissecting needles, microscopic scissors, forceps, and knives (Figs. 20, 21, and 23), may also be worked by the instrument. The needle

Fig. 20.

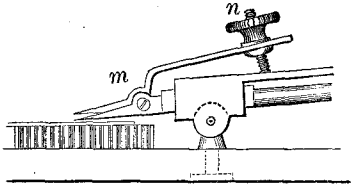


Fig. 21.

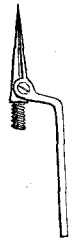


Fig. 22.

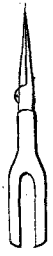


Fig. 23.

(Fig. 17, *l*) can be unscrewed, and other instruments substituted, as is seen in Fig. 20. The scissors (Fig. 20, *m*) are opened and closed by turning the nut (*n*), the notch of which is embraced and slides on the fork-like handle of the former (Figs. 20 and 22). The forceps are managed in the

same manner. Fig. 23 is a small knife for scraping off epithelium from small ducts, &c., after they have been cut open with the scissors.

The accompanying figures give so accurate a representation of this instrument, as to supply any deficiencies in my description. I have, however, to say that the threads of the screws are not represented as sufficiently close in Fig. 16. To Mr. Gemrig, No. 109 South 8th Street, I am indebted for the accurate construction of the instrument from my drawings, and I can cordially recommend him as one capable of executing any work of the kind. I am also under obligation to his workman, Mr. Wolf, the maker of the instrument, whom I consider the most accurate workman in his line I have yet met with in this country.

I cannot speak too highly of the instrument, for without its assistance, it would have been impossible for me to examine the microscopic structure of the liver so successfully. Yet it is, of course, susceptible of improvement, and by none more likely than my old friend Mr. Lüer, of Paris, whose well established reputation has no need of my indorsement.

The management of the instrument requires a little practice, as the object is reversed in most microscopes. In turning the nut by which the point of the needle is brought toward the glass, much care should be taken to preserve the point from injury, by pressure against the glass. No part of the instrument should be unsteady, while at the same time the motions should be easily effected, that the hand may detect the moment the needle-point touches the glass. The whole success of the manipulation depends on the accuracy of these movements. The point of the needle must be *very* fine; this is best accomplished on an Arkansas hone, and by the aid of a magnifying-glass of a low power. Sometimes, even with the greatest care and precaution, the point will break. To be obliged to apply to an instrument-maker to adjust it each time, would occasion much inconvenience. The investigator himself may obviate this difficulty, by annealing the needle first in the flame of a spirit-lamp, and afterwards bending the point, and then hardening and tempering it again. There is an inconvenience connected with the instrument, which, though slight, compared with its advantages, is scarcely noticeable, viz., when the point of the needle enters the liquid in which the tissues are dissected, the motion produced disturbs the rays of light, and confuses the appearance of the object; but this lasts only until the point of the needle has fairly entered the liquid and touched the tissue, when all will be as clear as before. The best liquid, therefore, to keep the tissues moist, will be one of a low specific gravity, which will allow the point of the needle to enter, without itself being too much disturbed. Water answers this purpose better than alcohol or turpentine, which evaporate too quickly. Glycerine, which is an excellent medium for the examination of tissues in other cases, is of too high a specific gravity for this purpose. The tissue should not have more liquid above it than is necessary for moisture, to prevent disturbance of the rays of light.

In using the No. 3 object-glass of my microscope (which is one of Nachet's), after the tissue is dissected, and properly adjusted for a favourable observation, it has been my custom to fill up the interspace between the tissue and the lens with water, or diluted alcohol, thus preventing any disturbance of the rays of light in passing through it, and also affording ample time before the evaporation of the liquid, for making any drawing.

The advantages and disadvantages incident to this, might be enlarged upon, but the operator's judgment and mechanical skill will readily suggest remedies for its defects; to its advantages, I can give my testimony, having used it without any difficulty. To manage the instrument successfully, delicacy of touch and a great deal of patience are required; but it is only by the latter, combined with perseverance, energy, and close observations, that scientific facts have, or ever will be, established.

Apparatus for making Microscopic Sections of Tissue.—This apparatus, by means of which I have made hundreds of the finest microscopic sections of various tissues and organs, is of even greater utility than the "Dissector." I designed it with the object of obtaining fine sections of the spinal marrow, or brain-matter, to aid in my researches on the nerve-structures. It seems worthy of remark, that at that time, in my references to the writings of several eminent investigators, I found the razor (which they considered the sharpest instrument), the only one regarded as most suitable for this purpose. This erroneous idea is readily accounted for; the razor having a very thick back, is more readily brought to a fine edge than any other knife. The reason is obvious; in honing a knife, the object is to remove the rough wire edge produced by the grindstone and polishing-wheel, and give to the blade another, smoother, and infinitely finer. Now, to do this, the nearer level we can render the two sides of the knife, the finer the edge. Or, in other words, the blade of the knife must form the same angle with the surface of the hone at each stroke, or the edge becomes round, and consequently dull. In honing the razor, less difficulty is experienced. The thick back will form an angle of the proper degree, when it rests on the surface of the hone, while, with another knife, much practice is necessary to preserve the same angle at each stroke. But the advantage of a keen edge which we obtain by using the razor, is counterbalanced by the clumsiness and thickness of the instrument in penetrating between the very fine slice of tissue, and the piece from which it is cut. Now, to avoid all these disadvantages, I have my knife, which is thin, arranged in such a manner as to enable every one to hone it with great facility; but I shall speak of this hereafter. Valentine's knife seemed to me useless for delicate, soft structures; it may do well enough for cartilaginous tissue; but even then, if the edge of one blade is not as keen as that of the other, it can never make a good section. As I have never used the knife, however, I can express no positive opinion about it.

In fact, it is almost impossible to make fine and uniform microscopic sections of the spinal marrow, of any considerable size, unless the knife be guided, by sliding over some smooth surface.

To accomplish this object, I at first cut a hole the exact shape of a transverse section of spinal marrow, in a small piece of thin board. Putting a piece of the former (previously hardened), through this hole, so as to project a little above the surface, I could slide a sharp scalpel over the surface, and cut fine sections comparatively easily. But there was still some trouble by the adhesion of the slice to the knife, which was remedied by cutting under water.

The *principal portion* of this apparatus (Fig. 24) consists of one plate upon which the pieces, destined to guide the knife blade move; a second

Fig. 24.

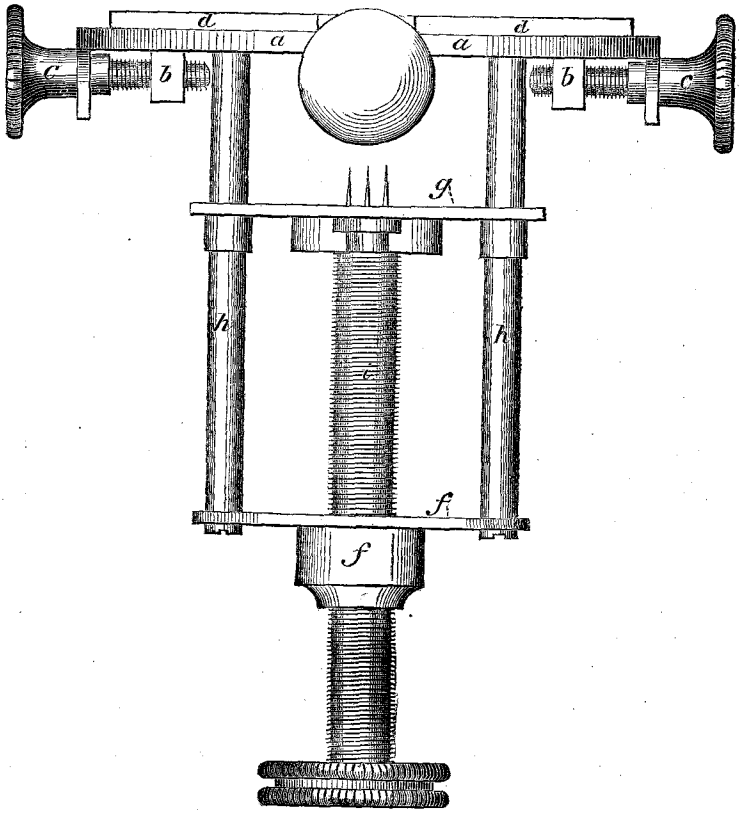
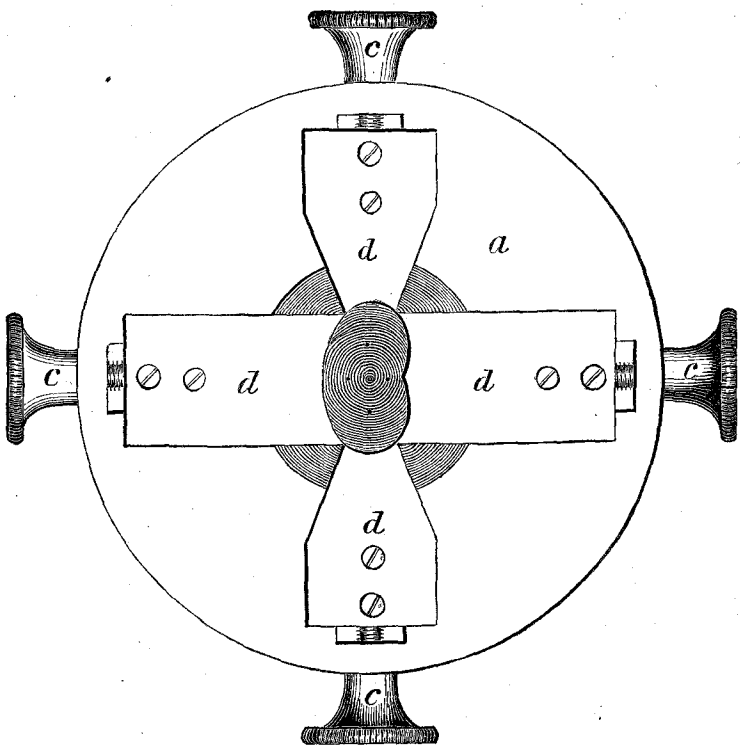


plate destined to hold the tissue to be cut; and a third one, in which the screw that regulates the thickness of the slices moves.

The plate (Figs. 24, 25, and 26, *a*) or stage of the instrument is round,

has a round orifice in the centre, and four others between the centre and the periphery. In each of these peripheral orifices a piece (Fig. 26, *b*) is made to slide forward or backward, by means of a screw (Figs. 24, 25, and 26, *c*) which turns in the plate (*a*). To the piece (*b*) can be attached smaller plates (*d* and *e*), which are intended to press against the sides of the spinal marrow, or other tissues, to hold them when cut; the surface of these plates (*d* and *e*) serves to guide the knife blade; by referring to the drawing, it will be noticed how they are attached to the pieces (*b*) by screws; it will also be observed how these plates can either be made to

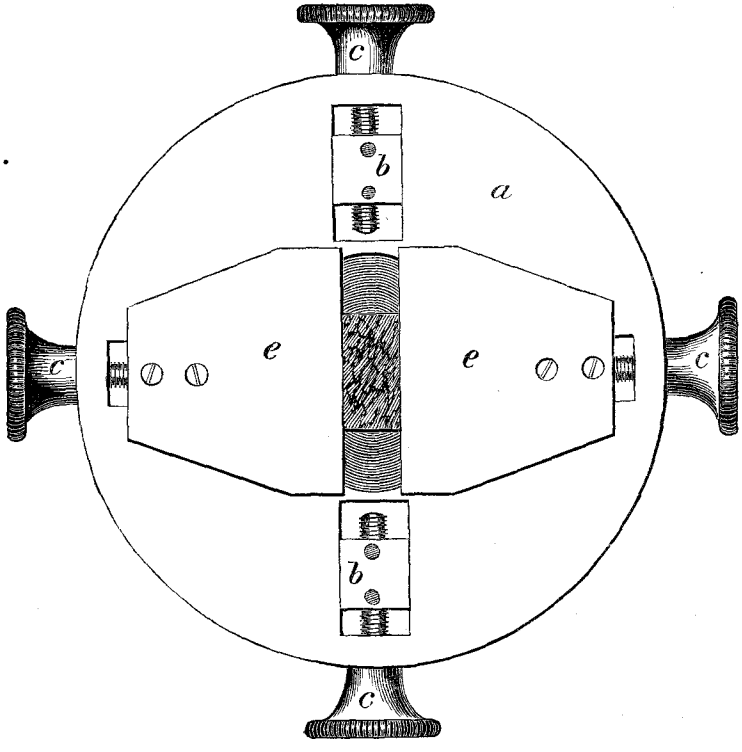
Fig. 25.



advance or recede by turning the screws (*c*). By this movement the preparation is held or loosened. The plates (*d*) in Fig. 25, as can be seen by their shape, are suited to hold a piece of spinal marrow; those in Fig. 26 (*e*) have their inner margins parallel to hold other tissues, as liver, kidney, &c. The plate (*f*), by means of four cylinders, is attached to the plate (*a*); these cylinders (*h*) assist in the accurate sliding movement of another plate (*g*) upon which the preparation rests; three sharp points can be seen upon this plate to prevent the preparation from moving sideways. A

screw (*i*), intended to move the plate (*g*), works in the plate (*f*), but by a notch is attached in such a manner to the plate (*g*), that it may turn freely in the latter. Now, when the screw (*i*) is turned, it will move the plate

Fig. 26.



(*g*), upon which the preparation rests, either upward or downward, and thus the thickness of the sections to be cut is regulated. The instrument should be made of brass.

As the cutting under water is one of the principal points in making good sections, I have a box of sheet tin, about one foot square, which is filled with water, and in which the instrument rests horizontally upon brass supports soldered to the bottom of the box.

As the spinal marrow varies in shape and thickness at different places in its course, there should be different sets of plates adapted to each portion. For the spinal marrow of small animals, two plates like Fig. 27 will be sufficient.

This instrument has been made to my satisfaction by Mr. C. Mannel, No. 704 Arch Street.

To make fine sections of nerves, an arrangement like Fig. 28 will an-

swer, which is a flat piece of wood, $\frac{3}{16}$ of an inch thick, with a little spring on each side to hold the extremities of the nerve. In making fine

Fig. 27.

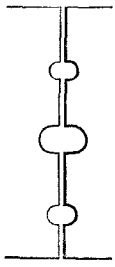


Fig. 28.

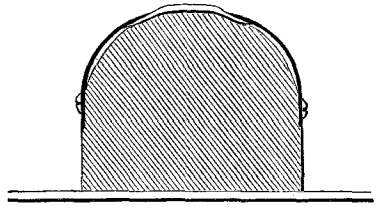


Fig. 31.

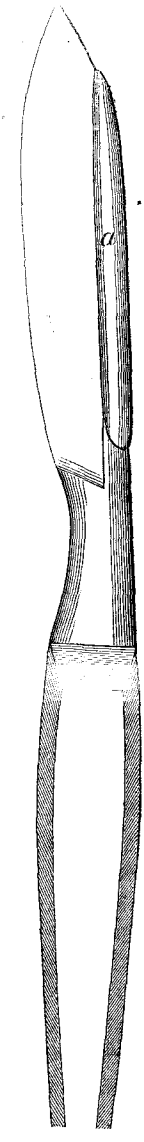


Fig. 29.

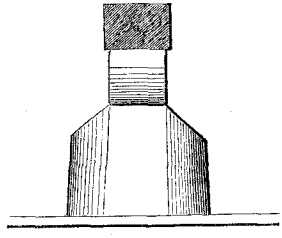
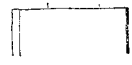


Fig. 30.



sections of liver, kidney, &c., or longitudinal sections of spinal marrow, I cut the piece, which shall furnish the sections, rectangular, and put it upon a piece of cork, provided with two little points, as is seen in Figs. 29 and 30.

The knife (Fig. 31) should be thin and very sharp, and slightly bent on one side, to prevent interference with the screw buttons; its back (*a*) is arranged to be slipped on, for the process of honing, and off when used for cutting. The cutting should be done from below upward, and by a scarcely perceptible sawing motion; if the knife is drawn only in one direction, the section will tear. If the section is well made, it ought to be thin enough to read fine print through it. In cutting spinal marrow, where four plates (*d*) to guide the knife and hold the preparation are required, care must be taken not to touch the angles of the plates with the edge of the knife in passing; for this purpose, those angles should be rounded off a little. After the section is cut and floating on the water, it is then caught fairly on a spatula, while yet under water. It is scarcely necessary to give more particulars in regard to the use of the instruments, the operator will soon discover them.

The Mounting Forceps (Figs. 32 and 33) was invented by me for holding the covering glass to the glass slide, when wiping and cementing its edges. It consists of a small forceps, to the jaws of which four little

Fig. 32.

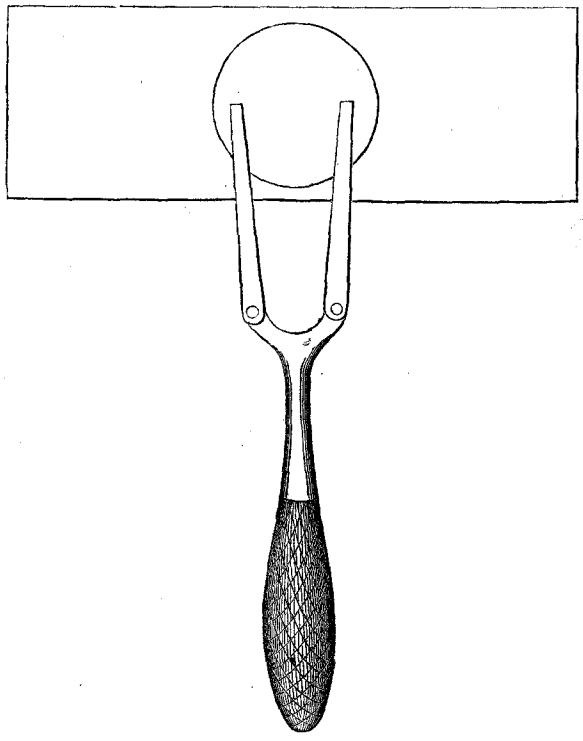
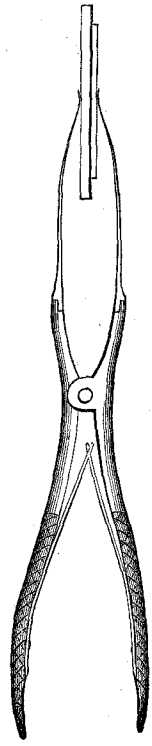


Fig. 33.



springs are attached, forming a movable joint; thus the distance between the extremities of the springs can be regulated, according to the size of the covering glass; the forceps is kept shut by a spring between its handles. This instrument will be found very useful for mounting microscopic preparations.

ART. II.—*Remarks on Sunstroke.* By JAMES J. LEVICK, M. D., of Philadelphia.

UNTIL a comparatively recent period there had been but little written on the subject of sunstroke, the name popularly given to those sudden attacks of loss of consciousness, with laboured respiration and prostration, which occur in such numbers during the summer season.